JPRS 78837

26 August 1981

West Europe Report

SCIENCE AND TECHNOLOGY

No. 71

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service, Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semi-monthly by the National Technical Information Service, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Indexes to this report (by keyword, author, personal names, title and series) are available from Bell & Howell, Old Mansfield Road, Wooster, Ohio 44691.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS 78837

26 August 1981

WEST EUROPE REPORT

SCIENCE AND TECHNOLOGY

No. 71

CONTENTS

ENERGY

Results of National Wind Energy Research Program Reported
(ENERGIE SPECTRUM, Jun 81) 1

Various Techniques Explored, by J. Pelser
Lievense Plan, by L. W. Lievense

Present State, Future of Solar Photovoltaics Assessed
(Holger Zeltwanger; ELEKTRONIK-APPLIKATION, No 4, 1981)... 10

Europe's Largest Coal Hydrogenation Plant in Operation
(DER TAGESSPIEGEL, 9 Jul 81, VDI NACHRICHTEN, 17 Jul 81).. 24

Plant in Bottrop
New Technology

TRANSPORTATION

Airbus Number Two in World
(TECHNISCHE RUNDSCHAU, 2 Jun 81) 26

Swedish State Railway Studies Hydrostatic Drive for Trains
(ZEITSCHRIFT FUER EISENBAHNWESEN UND VERKEHRSTECHNIK,
Jun 81) 27

RESULTS OF NATIONAL WIND ENERGY RESEARCH PROGRAM REPORTED

Various Techniques Explored

Amstelveen ENERGIE SPECTRUM in Dutch Jun 81 pp 163-167

[Speech by J. Pelser, director of ECN, on 18 May 1981, during conference on "Wind Energy in the Netherlands"; place of speech not given]

> [Text] The text of this article was taken from a speech, given by engineer J. Pelser, director of the ECN [Netherlands Energy Research Center] on 18 May, during the conference on "Wind Energy in the Netherlands." Following the report on 5 years of the National Wind Energy Research Program, this conference provided a detailed analysis of the report in question and related aspects.
>
> In 1976, the National Wind Energy Research Program got off the ground by defining a number of research projects, which have currently been totally or largely completed. Special mention should be given to the research on storage systems. In 1975, the Project Preparation Group advocated exploratory research on high capacity storage systems, in relation to which the view was expressed that, given the small differences in altitude in the Netherlands, the probability of water being pumped up into reservoirs would be nonexistent. Since 1979, there has been a plan, presented by engineer Lievense, in which he proposed a combination of wind energy and storage basin accumulation. Meanwhile, a report on this plan has been issued by the Committee for the Preliminary Study of the Lievense Plan; the proposed storage method is very interesting, because in this way a number of objections relating to the implementation of wind energy can be cleared away.

Meteorology

Within the framework of the National Wind Energy Research Program, the KNMI [Royal Dutch Meteorological Institute] has gathered the wind data most relevant for the Netherlands, put them into more usable form, and further elaborated on them. These activities involve the reduction of wind data, as they have been measured for years by the KNMI, on the one hand into representative velocities as they would occur in open terrain and, on the other hand, into velocities at an altitude of 40 meters. Furthermore, the distribution of the wind velocity in terms of the direction of the wind, and the distribution of low wind periods were studied. Attention was also given to data obtained from measurements over the North Sea.

The conclusion we can draw is that a number of existing data have been processed in such a way that a usable package of information, necessary for the implementation of wind energy, has been developed. Alas, no specifically new data have become available within the framework of this research program, which would be significant for the generation of energy with the aid of wind. This involves, among other things, measurements at a 40 meter altitude level, in order to be able to verify the results calculated within the framework of the program. Neither has any new information become available with regard to expectations of the short term wind supply and its behavior over short periods of time. The limited capacity of the KNMI to carry out research and various other priorities have had a limiting influence here. These data are very important, specifically for the application of wind turbines and parks, whereby energy is delivered to the public system. A further study of this will be necessary.

Technology

This subject can be divided into three areas. The wind turbine with horizontal axis, the wind turbine with vertical axis, and a new development in the area of the wind turbine with horizontal axis -- the so-called tip-vane system. The most advanced in development is the wind turbine with horizontal axis. Such a turbine, with a rotor diameter of 25 meters and a 300 kilowatt electric generator, was designed within the framework of the National Wind Energy Research Program, built and set up on ECN land in Petten. The goal was not to build a prototype production machine, but rather to develop a measuring installation in preparation for the construction of wind turbines of greater size and capacity.

This is why this wind turbine has been equipped with elaborate instrumentation, in order to be able to register clearly its behavior during periods of fluctuating wind loads. Moreover, this machine will make it possible to check the manner in which the turbine should be regulated, in order to deliver an optimum amount of electrical energy to the system.

The design, calculations and building of this wind turbine have provided important experience, which will be very useful for the future industrial production of wind turbines. Based on the currently available data, they could simply build a wind turbine with a 25 meter diameter for the production of electricity. When the measurement data of the turbine located in Petten become available shortly, it will also be possible to design and build larger wind turbines, with a capacity of, for example, up to 1 megawatt. In order specifically to give industry in the meantime the opportunity to learn to manage the larger scale production of wind turbines and to get to know the behavior of a number of wind turbines working together, it will be necessary to proceed as soon as possible with the building of a park with, for example, 25 turbines with a capacity of 300 kilowatts each.

Also important are the studies which have been carried out concerning the conversion of mechanical into electrical energy. These have provided insights into the possible application of a synchronous rotary generator with post-connected battery-charger and alternator, which would allow for a considerably improved coupling with the system compared with the synchronous or a-synchronous rotary generator, directly coupled to the system, generally used abroad. Measurements obtained from the 25 meter wind turbine in Petten should provide a definite answer to the question of whether this is indeed the case.

Technology (mechanical) I

Activities : 25 meter horizontal axis turbine designed and built
Results : unique measuring instrument
Sequel : operating results

Tip-Vane System

Pioneering work has been done by the staff of the Technical College at Delft. By fastening small auxiliary wings to the ends of the rotor blades of a wind turbine, it became possible to increase substantially the quantity of air going through the rotor. This way, the same diameter rotor could produce a substantially larger quantity of energy. This could, for example, result in a 60 to 70 percent increase of the energy yield at an estimated 15 percent increase in costs. A great deal of research remains to be done before this principle can be applied in the production of wind turbines. Due to the expected reduction of energy costs, it is extremely important that this research be continued further.

Technology (mechanical) II

Activities : development of tip-vane rotor
Results : working of tip-vanes established
Sequel : demonstration

Vertical Axis Wind Turbine

This turbine is based on a principle which was already patented in 1929 by the Frenchman Darrieus. However, it took until 1975 for this system to be rediscovered by the Canadians. Since then, research on it has been conducted in a number of locations in the world. In the Netherlands, such a turbine with vertical axis was built during the years 1975 and 1976, in the framework of the National Wind Energy Research Program.

A number of experiments were carried out with this turbine, which had been set up on the property of the Fokker airplane factories at Schiphol. The vibration of the turbine as a whole and of the rotor blades in particular was measured, its behavior in a gale wind under emergency conditions was studied, and the kind and velocity of the wind surrounding the wind turbine were studied with an eye on the wake effect. A number of aspects in the aerodynamics and the aero-elastic behavior of a turbine with vertical axis were not yet known at the time this turbine was designed. The result was that a number of measurements made it clear that it is not always possible to measure that which one would have liked to measure. Thus, no answer could be provided to the question of how to choose the design parameters for scale enlargement. On the other hand, however, the experience obtained with the 5 meter vertical axis turbine was very important for the insights it provided in relation to the choice of instrumentation for the 25 meter horizontal axis turbine in Petten.

Technology (mechanical) III

Activities : vertical axis wind turbine [VAT] (measurements on 5 meters)
Results : limited data on VAT
Sequel : design and construction of 15 meter VAT

Based on the experiences with this 5 meter VAT, Fokker as well as Rijn-Schelde-Verolme have currently developed designs for turbines with vertical axes with a 15 meter diameter and a 25 meter diameter. It would be advisable to build such a wind turbine as soon as possible, in order that the results can be effectively compared with those of the 25 meter turbine with horizontal axis.

Planning and Mutual Influence

Results of the research conducted by a study group, consisting of representatives of the Ministry of Economic Affairs, the National Planning Service, the KEMA [Office for the Inspection of Electrotechnical Material] and the ECN, on the planning aspects of wind energy parks showed that, after eliminating those areas where the construction of wind turbines is absolutely impossible (water, roads, farmland, woodlands), in the zone where the wind velocity is at least 6.5 meters per second, there remains an area which could accomodate a maximum of 30,000 wind turbines if there were no other limitations.

That this does not involve real space is apparent from the fact that about 25 percent of the area involved could be filled with windmill parks. Hence, it is a purely theoretical solution and in practice it would turn out that numerous areas are already being used for purposes which would not readily permit the construction of windmills. Therefore, it seems to me that it would be useful to consider a limited area, for example in the tip of Noord-Holland or in Friesland, in order to make a detailed study there of what the real possibilities for placing wind turbines in an agricultural area are. Furthermore, it is true that, according to the theoretical view, if we limit ourselves to an area where the wind velocity is higher than 7.5 meters per second, this area could accomodate 10,000 wind turbines. Let us assume that 10 percent of that figure is real, then there would still be room for about 1,000 wind turbines. The possibilities of setting up wind turbines in the North Sea have also been looked at. A couple of areas have been noted along the Dutch coast, where at least a few tens of thousands of wind turbines could be built. Technically speaking, the possibilities seem to be there, but in terms of costs it should be expected that the energy produced would cost approximately twice as much as that produced by wind turbines on land. From this point of view, there can be no question for the time being of building wind turbine stations in the North Sea. A great deal of work, the results of which have also been presented in the international framework, has been done on the measuring of wake effects. A good understanding has been acquired of the capacity reduction resulting when the mutual distance between the wind turbines is reduced. As a result of these calculations, it can be said at the present time that the mutual distance can be smaller than had been assumed a number of years ago. Extensive attention was also directed to the turbulence structure behind a single rotor. It showed that this turbulence could well create an extra load on the rotor blades. Further research will yet have to be done to learn about the turbulence in complete windmill parks.

Technology (electrical)

Activities	:	conversion of mechanical into electrical energy
Results	:	preference for synchronous generator with battery-charger and alternator
Sequel	:	experimental verification

Coupling with System

Several figures could apply in terms of the total number of wind turbines which would be used for the public electricity supply of the Netherlands. This also applies to the number of smaller decentralized wind turbines which could be coupled to the public system.

The 1975 report of the Project Preparation Committee on wind energy indicated that in order to generate approximately 20 percent of that year's electricity production with wind turbines, approximately 5,000 wind turbines of 1 megawatt would be required. This report already noted that to set up such a capacity would certainly have consequences for the electricity production system, which should be thoroughly studied. But, it was said, the realization is not unimaginable.

Meteorology

Activities : existing data processed and reduced to usable form
Results : usable package of information
Sequel : specifically new information
- verification of 40 meter wind velocities
- short term predictions

However, the National Wind Energy Research Program has brought out the fact that a 5,000 megawatt wind energy capacity is a rather large capacity to be able to be absorbed at all times by the electricity system. If the minimal load is taken into account, then a much lower capacity is arrived at. If it is determined that no more than 20 percent of the peak capacity is ever to be produced through wind energy, then the limit lies somewhere in the neighborhood of 2,000 megawatts. However, if one approaches the matter in a substantially more conservative way and if one assumes that the wind energy capacity is a capacity which could suddenly at any time disappear due to a reduction of wind, then at that point the maximum capacity to be put into service would be the equivalent of the largest conventional unit. As a matter of fact, the structure of the system is currently geared to it and the operation is such that it is possible to absorb the loss of such a capacity. This capacity is approximately 650 megawatts. The question is whether all of this is very real, because under certain circumstances a much larger wind capacity could very definitely be accepted. If, for example, a 3,000 megawatt wind capacity were to be set up, then it would be conceivable that under certain circumstances -- for example, during the summer at minimum load -- its production might have to be limited to 2,000 megawatts. What should be looked into then is what the operating period would be for the 1,000 megawatts which cannot be fully used and whether it would still be profitable to build these wind turbines on the basis of this operating period. It is also very conceivable that under certain circumstances, the wind energy capacity might have to be limited to a capacity substantially below the 2,000 megawatt level. Such a situation could occur if short term wind expectations are for a rapid reduction of wind, while the electricity system expects an increasing power demand, for example between 6 and 8 o'clock in the morning.

Decentralized Applications

Activities : testing of windmills at test site in Petten
execution of demonstration projects
Results : will be obtained only later on from current projects

All of this should have made it clear that the use of wind energy will require a different kind of management in electricity companies than had been the case up to now, and that this management will have to be geared to it, which should be possible without endangering the reliability and operational dependability of the electricity supply. It should be obvious that the presence of energy accumulations in a storage basin would very strongly reduce if not eliminate these problems.

Costs of Wind Energy

The following can be said about the costs related to the generation of wind energy. If the investment in a wind turbine costs 3 million guilders per megawatt, then the cost per kilowatt-hour can be figured at 18 cents. This amount is not a criterion for determining whether wind energy is profitable, if no consideration is given to the fact that a wind turbine can only be considered as a partial replacement for conventional power. The presence of a 1 megawatt wind turbine capacity would mean that approximately 200 kilowatts less conventional power would have to be produced. If we assume the investment in 200 kilowatts of capacity to be 400,000 guilders, then the net investment would amount to 2,600 guilders per kilowatt. This investment would have to be compensated for by a fuel conservation of approximately 8 cents per kilowatt-hour. At the current rate of depreciation, this is not the case. However, if the investment in a wind turbine could be reduced to 2.5 million guilders, then the wind turbine would be profitable at a fuel price of approximately 13 cents.

Planning

Activities : research space aspects of large scale application
Results : theoretical approach to location possibilities
Sequel : detailed studies of real location possibilities

Considering the expected developments it would seem reasonable to assume that this situation will be achieved in a few years. Moreover, the certainty that for a wind turbine the kilowatt-hour price is determined at the time it is being built, that is to say that it is determined solely by investment costs, makes it a possibility that other criteria may have to be applied for the investment decision than is usually the case.

Aside from the large scale application of wind energy, increasing attention is being given to the so-called decentralized application. This could be an autonomous company, thus independent of the electricity system, possibly in combination with a diesel generator, or an application whereby coupling with the system exists anyhow. Both applications could be important for agricultural enterprises, for drainage of the polders or for isolated housing centers. Generally speaking, the wind turbines used here will not be too large in diameter, that is to say up to, for example, 10 meters and will have a generator capacity of approximately 20 kilowatts. At the present time, a number of enterprises in the Netherlands are intensively pursuing the designing and building of these smaller windmills. These kinds of mills are also being imported from abroad, specifically from Denmark; however, there are no reliable mills on the market yet with a guaranteed working life of, for example, at least 10 years.

Integration with Electricity Supply

Activities : research on incorporation of wind energy
Results : capacity to be incorporated under all circumstances is limited
Sequel : evaluation of operating period as function of wind capacity

Costs of Wind Energy

Activities : initial cost calculation for large wind turbine
Results : estimated cost per kilowatt-hour approximately 40 percent higher than with conventional

Mutual Influence

Activities : calculations and wake measurements in wind tunnels
Results : good insight into mutual influence of wind turbines
Sequel : experimental verification in the field

Not much practical experience has been acquired yet either. In addition, there is the specific question of whether the predicted fossil fuel conservation will be realized in practice and whether energy generation with these mills will entail a sufficiently low energy price for the consumer. Hence, in order to develop a sound understanding of the problems related to the decentralized generation of wind energy, it will be necessary to carry out demonstration projects for a number of representative cases. The goal of a demonstration project must not under any circumstances be the testing of certain components, such as the windmill itself. These parts should first be tested separately as to their safety and reliability, for example by a testing company at the ECN testing site in Petten, which is available for that.

Conclusion

As a general evaluation, it can be said that, within the National Wind Energy Research Program, the tasks which were formulated 5 years ago at the start have been carried out, with the exception of the 25 meter turbine with vertical axis project. All the auxiliary tasks have produced important data, all of which is necessary to permit the application of wind energy in the Netherlands. The question of whether wind energy can make a significant contribution to the energy supply of the Netherlands, can be answered with a straightforward yes, as long as the consequences of this application are accepted.

In closing, one last observation. There are many people in the Netherlands who believe, and rightly so, in the application of wind energy. However, they are apparently divided into a large number of groups. In this context, one might draw attention to a motto from a time when wind energy played an important economic role, specifically the motto of the Republic of the Seven Netherlands "Concordia parvae res crescunt": unity makes the small strong.

Lievense Plan

Amstelveen ENERGIE SPECTRUM in Dutch Jun 81 p 145

[Final Report on proposal by L.W. Lievense, issued by the Committee for the Preliminary Study of the Lievense Plan: "Wind Energy and Water Power"]

> [Excerpts] The interdepartmental Committee for the Preliminary Study of the Lievense Plan, set up on 4 June 1980, whose task it was to study the idea presented by engineer L.W. Lievense concerning the implementation of a storage basin for wind energy accumulation, has recently presented a report to the minister of science policy. The following ministries were represented on the committee: Science Policy, Transport and Waterways, and Economic Affairs; in addition, engineer Lievense had a seat on the committee.

Description of System

Based on the original idea of engineer Lievense, the committee's study gradually led to the WESP [Wind Energy and Electricity Storage Basin] system as presented here.

The WESP system consists of:

- a number of groups of wind turbines -- which may or may not be located close to the energy storage basin -- whose generated electricity can be made directly available to the public system, and via this system can also be used to pump up water into the storage basin.

- an energy storage basin, consisting of a water mass surrounded by high levees, in which potential energy can be stored.

- a number of water power stations on the levees of the storage basin, which will use the stored potential energy to produce electricity by letting the water flow off from the high basin down to the surrounding lower water level. Because the hydroturbines are reversible, they can also be used to pump water into the storage basin. To pump the water up, electricity obtained via the public system from wind energy or, if necessary, from conventional power stations during low consumption periods (night current), will be used.

Favorable Prospects

In the letter presented to Minister of Science Policy Van Trier, the Committee for the Preliminary Study of the Lievense Plan concluded in its final report "Wind Energy and Water Power" that "based on the current data, a WESP -- Wind Energy and Electricity Storage Basin -- for the purpose of producing electricity would yield such favorable results that from a financial-economic as well as an energy-political point of view a capacity of 1,600 megawatts within a single structure flow should be effected as soon as possible." This would require a hydro-capacity of 1,600 megawatts and a wind capacity of 2,000 megawatts.

If preparation and execution of the project are tackled with great speed, then the above mentioned capacities could be in production about 1995. If an economic growth of 2 percent per year were to exist, then the capacity in the year 2000 would have to be raised to 2,400 megawatts. This would require a hydro-capacity of 2,400 megawatts and a wind capacity of 3,000 megawatts.

Among the locations studied, the Markermeer is preferred. For this location the committee has predicted that, even with moderate economic growth, by the year 2000 it will present a positive balance of 687 million guilders per year, and with 2 percent economic growth up to a possible 941 million guilders per year, all of this calculated in 1980 guilders. Because of the possible savings on fossil fuels, positive effects of 1 to 2 billion guilders per year may be expected in the balance of payments by the year 2000.

The impact on employment in the Netherlands was estimated at approximately 71,500 man-years for the full implementation. As an additional step in the study of the WESP, the committee deemed it necessary to further study the planning involved and the environmental management which had been inventoried in a tentative study.

According to the letter presented, the committee deemed it equally necessary to pursue the study of, among other things, problems related to:
- wind energy and wind turbines;
- optimalization of the relationships between the wind capacity to be installed and hydro-capacity;
- the civil engineering-technical projects.

8463
CSO: 3102/363

PRESENT STATE, FUTURE OF SOLAR PHOTOVOLTAICS ASSESSED

Essen ELEKTRONIK-APPLIKATION in German No 4, 1981 pp 28-35

[Article by Holger Zeltwanger: "Photovoltaic Current Generation--A Renewable Energy Source"]

[Text] All industrial countries are making major efforts to develop economical methods for the conversion of solar radiation energy into thermal, electrical, or chemical energy. The most intensive work is being done in the fields of thermal and photovoltaic energy conversion. This technical report deals exclusively with photovoltaic current generation, a renewable energy source which of course is not yet being used on an industrial scale.

It has been estimated that the earth gets a radiation output of 10^{18} kwh per year from the sun. This irradiated energy corresponds roughly to 10,000 times the world's current energy requirement. In western Europe, energy irradiation annually comes to $1.7 \cdot 10^{15}$ kwh and in the FRG it is $2.5 \cdot 10^{14}$ kwh.

Because the earth's temperature on the average is extensively constant, the radiation output must practically be completely returned again into space. About 30 percent of the radiation do not reach the earth's surface due to reflection along the air envelope; another 47 percent of radiation are converted into heat and are reflected again during the night. Most of the remaining 23 percent first of all cause evaporation of water. During subsequent condensation, the stored energy is again released in the form of heat radiation. About 0.2 percent account for the generation of air movement as well as waves and about 0.025 percent account for the photosynthesis of plants.

Available Solar Energy

The sun's radiation output in space is almost constant (1,353 W/m^2). On the earth, the radiation output and its spectral distribution depend on the particular weather, the seasonally conditioned incoming radiation angle, and the daily duration of sunshine.

Thus, the sun appears for about 3,500 hours per year on the equator. In Munich we have 1,800 hours of sunshine and in the Ruhr region we only have 1,500. The average annual global radiation figure (diffuse radiation + direct solar radiation) in the Sahara is more than 2,200 kwh/m^2 and in Central Europe it is 800-1,100 kwh/m^2.

To have a possibility for comparison, the following definition was agreed upon: the radiation conditions existing outside the earth's atmosphere are designated as air mass 0 (AM $0 \approx 1.35$ kw/m^2). The most favorable incoming radiation condition on the earth's surface is (AM $0 \approx 1$ kw/m^2) with perpendicular incidence and a clear sky.

If the incoming radiation angle is smaller than 90°, then we get AM values which result from the reciprocal value of the cosine of the incoming radiation angle. AM 2 (0.75 kw/m^2) thus represents an incoming radiation angle of 60°; this value applies in the FRG during the summer months. With a slightly overcast sky in the summer, the radiation output is still 300-600 W/m^2. In case of heavy cloud cover, we have 100-300 W/m^2 and during the winter months we can figure about half of that.

In spite of the gigantic energy volume, which the sun radiates upon the earth, solar energy is so far hardly being used. Only the rising cost of fossil energy sources (oil and coal) and the continuing criticism of atomic energy push the use of solar energy.

The principle of photovoltaic current generation has been known for more than 100 years. So far, solar cells however have been used only in isolated cases for space travel. These solar cells now cannot be used for terrestrial purposes because, on earth, we have a spectral energy distribution of sun rays which is different from what it is in outer space.

Current Status

The three biggest solar cell producers are affiliates of American oil corporations such as Solarex Corp. (Amoco affiliate), Solar Power Corp. (Exxon affiliate), and Arco Solar Inc. (Atlantic Richfield affiliate). Each of these firms has an approximate annual output capacity of 1 Mw. Worldwide, 5-6 Mw were produced last year.

In Europe, it is especially AEG [General Electric Company] and RTC (until now a Philips affiliate) which are involved in the production of solar cells. A short time ago, Siemens also ventured into this business. According to statements by Solartechnik sales manager Klaus Kaesen, Siemens is setting up a production facility of its own in Regensburg. Production is scheduled to start in 1982. Until now, Siemens had been getting its solar cells from Valvo/Philips, with whom a semiconductor delivery agreement had existed for the past 15 years.

In view of the dominant position of American oil affiliates, Kontron production manager for Solarsysteme Georg Schmidt, thinks that "the electric power industry has been asleep at the switch." Indeed, we cannot see much of AEG here and Siemens has just jumped on the solar bandwagon. The people at Siemens do not consider this necessarily as a disadvantage. According to Klaus Kaesen, Siemens considers solar electronics to be a system operation which is why they think they are superior to some extent to the oil affiliates. He does of course expect the oil corporations to work with the electric power corporations once the industrialization of photovoltaics begins.

But it is not quite correct to blame the German electric power industry alone for all it has failed to do although it did put its cards on atomic energy for entirely too long and in too exclusive a fashion.

The West German government's promotion policy also leaves something to be desired. On the one hand, they recognized the possibilities of photovoltaics far too late and on the other hand many people criticized the way in which money is being given out. In the FRG, AEG-Telefunken and Heliotronic, an affiliate of Wacher-Chemitronic GmbH [Incorporated] were commissioned early in 1978 to conduct "an investigation and the development of industrial manufacturing technologies for terrestrial solar cell generators and the suitable basic materials."

It is not yet certain to what extent Siemens is being subsidized.

In the United States, in addition to annual subsidies of $250 million, other important decisions are being made which are designed to make the use of solar cells attractive. For example, the electric power companies must purchase energy generated from private individuals by means of solar cells at favorable prices. Another way to make the use of solar electronics worthwhile would be to have your "house" (local grid) disconnected from the public grid in order to be able to switch to your own supply system, at least during the noon hours. It is especially the smaller companies which today already market solar cells in the FRG and which complain that the promotion funds are not being scattered widely enough and that users are not being sufficiently subsidized. Early this year, EG however adopted 18 projects with 1.4 Mw in which the West German government is also participating.

"There is too little promotion work being done," complained Helmut Rechberger, the business manager of Atec GmbH and with tears in his eyes looks to France where the government publishes official government advertising pamphlets. "That sort of thing costs a lot of money and this is what the small companies have to do in the FRG themselves," according to Helmut Rechberger. Joachim M. Tuebcke, the business manager of Solarelektronik GmbH, feels that the big companies, especially AEG, are getting preference in the federal government's promotion policy.

Prognoses and Estimates

Siemens expects a world output growth rate of 2.5 per year until 1985. After that, the growth rate will level off somewhat. According to Klaus Kaesen, they expect a world market of 20-25 Gw for the year 1990.

Wacker-Chemitronic is somewhat less optimistic; that is one of the most important raw material suppliers for solar cells. For the year 1990, the Solar-Material sales manager Norbert Ayberger predicts a worldwide output volume of 100 Mw. The American DOE is about as optimistic as Siemens and predicted a production volume of 500 Mw for 1985.

Although Fritz G. Vieweg-Gutberlet, the technical marketing manager, claims that "Wacker-Chemitronic is aware of the obligations to meet the need for silicon," one may certainly doubt that the efforts of silicon suppliers will be sufficient to attain the figures predicted by Siemens and the DOE. This is especially true since, according to the 1982 Schuhmacher report, we can expect for the first time that the requirement curve for silicon (excluding solar cells) will by far exceed the installed capacity worldwide. Even though doubt has been voiced in the meantime about the report, this mostly involves only a time shift of 1-2 years.

Nevertheless, the efforts made by Wacker-Chemitronic are quite considerable. By the end of 1981, the production capacity for polycrystalline silicon at Burghausen is to be increased from 1,200 today to 1,800 t/yr. Besides, a new factory is being built in Portland, Oregon, which is likewise supposed to supply polycrystalline silicon by 1983. For comparison: last year, about 3,000 t of polycrystalline silicon were produced in the western world, including Japan.

The central point as to whether photovoltaic current generation can provide an essential portion of energy generation involves economy. Because silicon will remain the basic raw material for solar cells, the following figures relate to this basic material. It has not yet been finally decided whether monocrystalline or polycrystalline silicon or some other technology will prevail. But the basic material will probably remain silicon.

We distinguish between the costs for solar cells and the module costs whereby, according to data from Siemens, 40 percent of the module costs go for silicon, 30 percent for cell production, and 30 percent for module production. Klaus Kaesen start with the assumption that "silicon, as basic material, can be reduced in terms of cost by a factor of 10 if one arranges the highly energy-intensive purification processes in a somewhat more clever fashion." By the middle of the eighties, the Siemens sales manager expects a solar cell price of DM 3-5/Wp (Wp = electric output of one solar cell under AM 1 conditions, that is, AM 1 $\approx$ 1 kw/m^2). Today, the costs are about DM25/Wp and 10 years ago they were still DM2,000/Wp. Looking at panels, the price today is DM30-50/Wp. Professor Hans-Joachim Queisser of the Max Planck Institute in Stuttgart even expects a price reduction down to DM1/Wp for the cost of the cells by 1985. Wacker-Chemitronic expects a price development for solar cells which is illustrated in Figure 7.

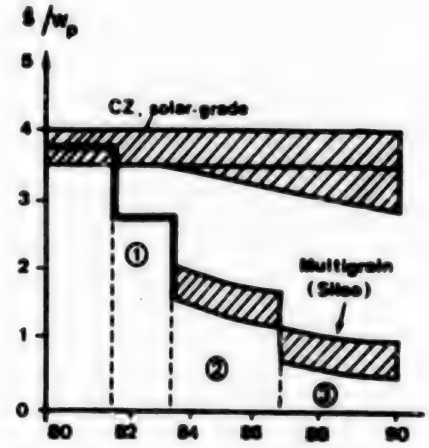


Figure 7. Price prediction for solar cells: 1. Improved casting processes; 2. Better methods for disc production and cheaper raw materials; 3. Use of "Silso" (Factory photo by Wacker-Chemitronic).

Freddy Jaeger, a staff member at the Fraunhofer Institute of System Engineering and Innovation Research, expects a panel price of $1-2/Wp by 1990. Figure 8 illustrates the expectations of the Department of Energy which is similar to those of Siemens. Valvo assumes that a price drop of 20 percent per year by the end of the eighties is not entirely unrealistic.

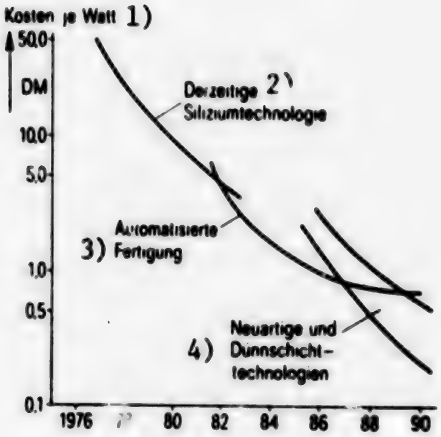


Figure 8. Cost prediction for solar cells by Department of Energy, U.S.A.,(source: Siemens. Key: 1--Cost per watt; 2--current silicon technology; 3--automated production; 4--novel and thin-layer technologies.

There are various economy limits also for differing uses. In the case of "island solutions" and for uses where there is no central supply network, the solar cell today already is an alternative for other energy sources (Figure 9). Uses in private households according to an American study become worthwhile only if the system costs are around $1/Wp. Solar cell systems for central current generation are profitable only if the system costs drop below $1/Wp. This, according to the study, will not happen before 1990.

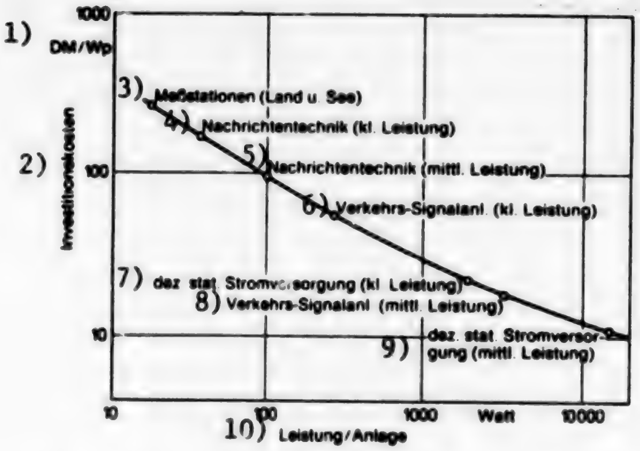


Figure 9. How big would the investment costs for solar systems be in connection with various uses? (Factory illustration: Siemens). Key: 1--DM/Wp; 2--investment costs; 3--measuring stations (on land and on the sea); 4--communications equipment (small output); 5--communications equipment (medium output); 6--traffic signal systems (small output); 7--decentralized stationary current supply (small output); 8--traffic signal system (medium output); 9--decentralized stationary current supply (medium output); 10--output per plant.

Uses

At this time, photovoltaic current generation is still in the preindustrial stage. "In the FRG, the emphasis is still on the sparetime sector," according to Joachim

M. Tuebke, business manager of Solarelektronik GmbH, "and the export business is only in its beginnings." The other suppliers of solar cells and modules likewise consider the domestic market to be mostly a type of consumer business deal. According to Kontron staff member Georg Schmidt, "industrial projects have long start-up times and the export business is still in the pilot stage." Nevertheless, Kontron already has 40 percent of its sales volume in the export business. Those of course are indirect exports, in other words, solar modules are sold to companies which then export solar systems plus water pump or television transmitter.

Siemens thinks in terms of world market criteria and believes that the main sales region for solar systems will be between the two 40th degrees latitude. This results in the following major points of utilization:

Systems for irrigation and drinking water procurement;

Systems for the supply of consumers far from the public grid or who are difficult to reach, such as measurement stations and communications equipment facilities;

Supply of "island networks" in the countries of the Third World.

M. Guenther, the product manager of the Sonnenschein Storage Battery Factory, estimates the market potential for solar-energy-supplied current supply systems at $100 million by 1985.

Consumer Sector

The solar cells used for energy supply in wristwatches and pocket computers probably represent the type of use involving the least electrical output. Such watches and pocket computers can be purchased already today.

Other products, which in the future are to be equipped with solar cells, are small radios, IR remote-control transmitters, flashlights, motion picture cameras, etc. In order to provide intermediate storage for energy, we use NiCd batteries. By replacing short-life dry batteries with long-life storage batteries, e can also reduce the environmental pollution.

A second attractive market for the consumer industry, according to Siemens, is to be found in the recreation field, for example, charge units for batteries on sailboats, in campers, vacation homes, and mountain cabins. But the solar cell has no chance where the electrical power supply network already exists.

There are utilization possibilities also in agriculture, for example, electrical pasture fences, fish weirs ventilation, irrigation of orchards and vineyards.

'Solar Homes'

For some time now, there have been "solar houses" in the United States whose electrical and thermal energy needs are covered at least partly with solar cells and solar collectors [panels] (in thermal terms). In Germany likewise, several companies are selling roofing tiles with built-in solar cells.

The biggest private photovoltaic system in the FRG is in Birnbach. It consists of 36 modules at 33 Wp, each.

If solar cells are to be used also in normal households, several problems have to be solved. Because the solar cells supply DC and because most consumers today need AC, the direct voltage must be converted into alternating voltage or you need new household appliances which will be operated through a second network for direct voltage. In the first case, a way would also have to be found either to feed the locally generated energy into the public grid or to separate the local network (house) from the public grid. This is not so much a technical but rather a political problem.

In order to make the use of solar cells more attractive, electrical appliances would also have to be changed. At this time, luminescence lamps are being developed and they have five times the light yield compared to the old product. Here is how Joachim M. Tuebke expresses it: "We must learn to handle power economically."

Some of the uses which as yet should not be taken quite seriously involve solar-energy-driven mopeds and four-wheeled vehicles. A single-seat aircraft, whose electric motor is driven by current from solar cells on the wings, already has its maiden flight behind it.

The Suntronic Company in Hamburg has just tested a four-wheel mobile and after successful completion, a solar-energy-driven vehicle for disabled persons is to be developed.

Pilot Projects

It is especially the Department of Energy of the United States which has supported a series of pilot projects. Early this year, EG also launched a major program totaling 18 projects with an installed output of 1.4 Mw. Most pilot projects involve power supply systems for use in the Third World.

Pumping systems with just about 1 kw have been installed already by almost all solar cell producers, for example, in Mali (Solar Power) or on Corsica (RTC). Another example involves the 24-USW stations in Australia (Solar Power), whereby more than 1 kw of output is produced in every station. Arco has built up a photovoltaic system (about 11 kw) to supply a directional radio system. This 360-km long directional radio link (Saudi Arabia--Sudan) has been working perfectly since 1979. Many of the pilot systems are power supply units for communications systems, for example, microwave amplifiers, radio and television converters.

A study by SEL AG on primary supply for directional radio systems shows how interested the communications equipment industry is in this development. According to that study, solar generators will be competitive in 1988 against 450-w double-diesel systems.

Several solar systems have also been installed in the United States and Europe, for example, an energy supply system for a gas station in West Chicago with an output of 5 kw (Solarex). Another example is a solar generator with 90 w for a cathodic corrosion protection system on a bridge along the George Washington Memorial Parkway (Solarex).

In France, stationary solar generators are being used for energy supply at railroad crossings (RTC). In the FRG, AEG has equipped some of the emergency phones in the Black Forest and light buoys for the North Sea with solar cells. Siemens recently laid a telephone line to a mountain cabin in the Alps which is operated with solar energy.

Solar Power Plants

Small photovoltaic power plants with outputs of up to 360 kw are under construction and partly also already in operation in the United States. Photovoltaic generators are probably being used here with concentrators. Sunlight is concentrated with the help of reflectors or lenses and only then is it aimed at the solar cells. Larger systems of up to several Mw will not be completed before 1990.

Solar power plants in desert regions, which generate hydrogen through electrolysis and solar power plants in outer space likewise are still only projects which are far off in the future. In the case of the hydrogen plantations, electric energy is to be used to produce hydrogen through the electrolysis of water or acids and that hydrogen is supposed to be stored, condensed, and transported. Photovoltaic power plants, which would circle the earth as satellites, are supposed to convert the incoming solar energy into microwaves and are supposed to transfer it in the form of beams to a receiving station on earth. Of course there is no information as yet on the influence of the microwave ray upon the ionosphere and the extent to which radio traffic and radio astronomy could thus be disturbed. Likewise unsolved is the problem of preventing deviations of the microwave ray from the receiving antenna to avoid damage to human beings and animals.

The main problem in solar power plants is storage. The operation of earth-bound photovoltaic power plants will presumably take place in conjunction with thermal power plants. The latter could then balance out the fluctuations in solar energy and solar power plants could work without storage units. Another possibility consists of pump storage plants which have for a long time been used to store surplus energy.

The Solar Cell Is the Heart

The heart of a photovoltaic system is the solar cell. Here we have precision semiconductors which convert the incident light rays into electric energy. They supply a voltage which is independent of the cell surface. The current generated on the other hand is directly proportional to the surface and the radiation intensity. In case of optimum insolation, the current densities of silicon cells--hitherto used most frequently--are about 25-30 ma/cm^2. The voltage is about 0.5 v. The lifetime is between 10 and 20 years.

So far, solar cells have been built up as large-surface semiconductor diodes with a homogeneous pn transition. But there are also experiments to make other cells in order to achieve greater efficiency or to be able to save certain steps in the process. Examples are Schottky diodes, tandem cells (two p-n transitions), cells with vertical transitions, and cells with multiple transitions.

The efforts of solar cell producers and raw material suppliers are all aimed at developing cheaper initial materials and attaining higher efficiencies. The industry is being supported here by research institutes, such as, for example, the Max Planck Institute for Solid Body Research in Stuttgart. Another decisive factor is whether the method is suitable for automated production.

In the case of solar cells made of silicon, we distinguish monocrystalline and polycrystalline silicon. So far, we have mostly been using monocrystalline silicon.

Solarex is now also delivering a semicrystalline cell. AEG likewise has established a production facility for polycrystalline solar cells; the silicon for this is being delivered by Helitronic GmbH. Because it has not yet been decided which technology will prevail, many producers work with both materials.

Silicon Cells

Because silicon, after oxygen, is the second-most-frequent element in the earth's crust, there are actually no raw material problems. The starting material mostly is quartz sand (SiO_2). Through reduction with coal in a light arc furnace, we get so-called metallurgical silicon. Through reduction with hydrochloric acid, trichlorsilane is being produced at 300° C. After purification, silicon rods are made at temperatures of around 1,000° C through reduction with hydrogen. Now we have polycrystalline silicon.

To get monocrystalline silicon, the polycrystalline silicon must be melted in a pot. A monocrystalline rod is then drawn out of the melted substance. Another possibility is to draw a melting zone through the polycrystalline silicon rod through which crystallization to form a monocrystal will take place. These rods are cut into discs, polished, and cleaned. Afterward, a phosphorous layer is diffused into the discs, and the p-n transition is thus established.

The reverse side of the cell is completely metallized for electrical contacting. The other side is provided with metallic conductor strips and with an anti-reflection layer. Through this anti-reflection layer and by roughing up the surface, we can reduce reflection losses. The efficiency of monocrystalline silicon cells is theoretically at 22 percent. Under production conditions, we can currently get 12-16 percent. These numbers apply to the presently customary 4-inch discs.

The production costs for silicon solar cells consist of 33 percent for silicon discs, 57 percent for cell production, and 10 percent for other materials. Measures to reduce the cost therefore will be undertaken mostly in connection with cell production and the production of silicon discs. One should above all avoid energy-intensive purification processes.

To save material, some producers are considering a reduction in the cell thickness from 350 μm to 50 μm. The development of methods for the encapsulation of cells is also in its beginnings.

In order to save costs during material production, we try to use silicon with lesser chemical purity. Besides, we are working on new methods for procuring polycrystalline silicon. During mechanical processing--especially during sawing--one can save costs, for example, by reducing the width of the cut, by increasing the cutting speed, or by using multiple wire saws. Another way is to draw the silicon crystals out of the melted substance in the form of strips which eliminates the sawing costs. The starting material however has to be highly purified silicon.

To save process steps, we can also cast the silicon into tube-shaped blocks and sheets. The blocks of course must be broken down into discs by sawing. Wacker-Chemitronic/Heliotronic calls cast silicon by the name of "Silso" (silicon for solar uses).

Thin-Layer Cells

Thin-layer cells consist of an active or passive substrate, upon which thin polycrystalline or amorphous layers are steamed or dusted. One can also apply these layers through pyrolysis or electrolysis. We distinguish between cadmium sulfide, gallium arsenide, and polycrystalline silicon as well as cells made of amorphous silicon.

In the case of the CdS cells, we expect that we can achieve an efficiency of 10 percent. Of course, this efficiency depends heavily on the temperature. Another advantage consists of the toxicity and the very limited supply of cadmium. The situation is similar in the case of GaAs cells. They are also very toxic but they have an efficiency of about 25 percent. The raw material gallium exists only in small quantities on earth. Besides, GaAs is needed more urgently for semiconductor structural elements in the computer industry. So, that leaves us with silicon. The polycrystalline silicon cells are made by separation from silicon films upon a substrate consisting of metallurgical silicon. Here we get cells with an efficiency of about 10 percent.

Cells consisting of amorphous silicon have efficiencies of up to 5.5 percent. Because production is very cheap, we expect that amorphous cells will be used for purposes where space requirements play a subordinate role.

Semiconductor-Electrolyte Cells

Texas Instruments has developed a semiconductor-electrolyte cell where the electric energy, converted in the silicon spheres, is used for the electrolysis of hydrogen bromide. The components thus separated--that is, bromine and hydrogen--are transported in different tanks. In order to get electrical energy again, bromine and hydrogen are supplied to a fuel cell which, due to current removal, generates hydrogen bromide. The cycle is thus completed. The efficiency of these cells is 13 percent. One unsolved problem here involves the stability of the semiconductor photoelectrode against corrosion. The encapsulation of the cells is just as difficult.

Concentrator Systems

Because the efficiency of solar cells is improved as the radiation output increases, we are trying to cluster the solar rays by means of lenses and reflectors. In such systems, the use of solar cells with a high efficiency is quite worthwhile. One essential aspect for the success of these systems would be whether we can find cheap construction methods for the concentrator. It is a disadvantage here that these systems must be constantly watched and work efficiently only when the sky is clear.

Entirely different "concentrators" are being studied and developed by the Fraunhofer Society. These fluorescence panels can concentrate diffuse and direct sun rays. The stability of the panel plates is a problem that has not yet been solved.

Photovoltaic Systems

By means of series-connection and parallel-connection of individual solar cells, one can build up current supply systems with various voltages and outputs. The solar cells to be sure have a long lifetime but they are very vulnerable to mechanical stress. They are therefore built into solar panels.

The ability of the solar panel to withstand rocks, sandstorms, snow, hail, and environmental pollution is the secret of the long operating lifetime of solar systems. The careful processing and selection of materials also are very important because the solar panel's efficiency depends on that. On the panel level it is about 10 percent when we use monocrystalline cells.

For the forward surface, Arco uses heat-treated safety glass which is as clear as water. This special-grade glass containing little iron allows more light to pass through than ordinary glass. The panel's reverse side consists of a tough metal sheet which is impermeable to moisture. Besides, Arco is using a special lamination process so that there is a rigid bond between the glass, the cells, and the rear surface. The individual layers are melted together with polyvinylbutyral.

Another important point is the mechanical processing. In the case of the solar panels made by Arco, we have a strong aluminum frame which is locked reciprocally at all four corners.

The Solarex solar panel consists of carrier plate made of glass-fiber-reinforced epoxy upon which the solar cells are mounted and then cast with special, glass-clear silicon synthetic substance. This synthetic silicon substance is UV-resistant and protects the solar cells against corrosion. In order to be able to withstand stronger mechanical stresses, the surfaces is provided with a glass or synthetic substance cover.

At this time, solar panels are being offered on the market with various outputs ranging from 0.4 w to 35 w. Solarex is now also delivering a 70 w module with cells made of semicrystalline silicon.

If we want to store the converted solar energy, we today usually employ a storage battery. Manufacturers in recent years have further extended the lifetime of these batteries. The Compound Company has developed storage batteries whose self-discharge is less than 3 percent per month. Batteries made by Saft, Sonnenschein, and Varta are likewise very reliable and have a long lifetime.

To make sure that the output supplied by the solar panel can also be used in an optimum fashion, the manufacturers recommend a charge regulator (Figure 15). The Chopper charge regulators have the highest efficiency.

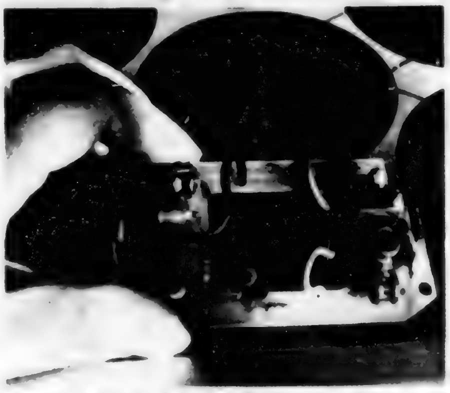


Figure 15. The charge regulator with SIPMOS output transistors can be placed in a 33 w panel (Factory photo by Siemens).

Siemens is even building an adaptation electronics unit which adjusts the resistance of the load circuit to the solar panel's characteristic curve and which thus provides for an optimum working point. Such circuits of course are very expensive so that they are worth the trouble only for systems in the kw range.

Deep-discharge protection is also needed for many uses and this might possibly be coupled with an alarm system. For protection against undercharging we also have load management systems which in case of undercharge danger first of all cut off the "luxury consumers." In other uses, for example, overload [overcharge] protection may be meaningful.

The field of adaptation electronics however is still in its infancy. The same is true of other system-engineering problems, for example, in the case of the VDE [Association of German Engineers] guidelines which cannot easily be converted for use with solar systems. According to Klaus Kaesen, Siemens is ahead of other companies in system engineering because Siemens can fall back on many years of experience in the field of rectifier equipment.

Dimensioning

The right dimensioning is a problem especially in the recreation sector but also in connection with the first export deals because many users are laymen electrotechnically speaking. Most suppliers of solar systems therefore ask the customer to fill out certain forms and the necessary size of the system is then figured out by computer.

But there are also companies, for example, Atec GmbH in Munich, which prefer manual calculation. The most important data are the available solar radiation and the profile of the required consumer output.

Summary

Photovoltaic current generation is still in its beginnings. In addition to technical and economic problems, there are also several political problems which must be solved.

Expectations and forecasts differ widely. We can only hope that solar energy will be used increasingly during the next several years because it does not entail the disadvantages of atomic energy and fossil fuels. Of course, the thermal use of solar energy will be considerably more important than the photovoltaic use.

The efforts of industry, above all on the part of the raw material producers, must be stepped up considerably if the forecasts by Siemens and the Department of Energy are to come true.

Photovoltaic current generation is a technique which can be handled in very simple fashion and which is also suitable for the developing countries. The only trouble is that those countries might thus not become more independent of the industrial nations because the production of solar cells demands a high technical knowhow. Even the relatively long lifetime of 20 years does not change anything on that.

The question comes up again and again as to whether the energy expenditure necessary for cell production can be recovered in a reasonably short time through solar energy conversion. This question indeed must be taken very seriously because, in any case, there will be a high energy requirement in the beginning as a result of the stepped-up use of solar cells. The "repayment rates" (energy payoff) under Central European weather conditions are between 2 and 3 years according to calculations by Professor Queisser.

Another problem connected with the industrial use of solar cells involves the environmental pollution. Here we might mention the aspect of landscape use and local heat supply. Because no cooling is necessary here, we do not have any water requirements either. Air pollution need be anticipated just as little as noise pollution. Of course, the use of "toxic" cells (GaAs and CdS) does constitute a threat because "cold" diffusion already can discharge toxic substances into the air. Traces of these highly toxic metals can then get into the soil due to rainwater.

Fluorescence Collector

By Professor Doctor A. Goetzberger and V. Wittner

The Institute of Applied Solid Body Physics of the Fraunhofer Society in Freiburg in recent years worked on novel collector systems which are particularly suitable for our latitudes; they can concentrate both directed and diffuse solar radiation. These research activities were taken over by the newly established solar energy systems study group.

The basic physical principle behind these collectors is the light conduction in transparent plates or fibers, such as it is being used today also in telephone and television engineering.

The starting material is a transparent glass or plexiglass plate which is doped with one or more fluorescent dyes. If environmental light I falls upon the plate, then it enters the collector and there it is absorbed by the dye and it is then emitted again in an isotropic fashion and shifted somewhat in a long-wave manner. This fluorescence light F_{1-3} is now conducted on the basis of the light conduction effect to the extent of about 75 percent in the plate and can leave the collector only along the edges. The concentration effect is based on the fact that we collect the light on large surfaces and that we can process it in a concentrated fashion along small edge surfaces.

In addition to the property to the effect that these collectors gather direct as well as diffuse sunlight, there is yet another property which distinguishes them from the conventional collectors: their spectral selectivity. Depending upon the choice of the dye or dyes, we absorb only a certain range of the incoming radiation. The advantage is that the outgoing concentrated light only comes out in a relatively small wavelength interval and that the absorber can be adapted to this wavelength in an optimum fashion. On the other hand, this selectivity means that a collector plate can process only a small part of the total incident energy. In practice we therefore will use a stack of different doped plates, each of which would absorb a spectral segment and would reflect concentrated light of differing wavelength which in the ideal case can be converted from differing, specifically adapted solar cells into current.

If we calculate such models theoretically, then, even assuming real dyestuff properties, we get total efficiencies of something like 10 percent. This magnitude is not very relevant so long as we know nothing about the concentration at which this efficiency is reached. Current experiments show that with a collector size of 1 m^2, we can achieve concentrations of 10-20. The biggest collectors investigated so far were squares with a dimension of 400 x 40 cm and a thickness of 3 mm. A single-stage collector absorbs about 20 percent of the incident energy. Its internal efficiency is about 40 percent so that about 80 percent of the incident energy will come out in a concentrated fashion at the edges. Depending upon the type of edge coverage [coating], this signifies a concentration factor of about 3-7, related to the total incident radiation flow. These relatively good figures however have so far been achieved only with dyestuffs which absorb in the short-wave spectral range and which fluoresce yellow to orange.

The development of new and better dyestuffs in the red and IR spectral range presently is the main point in the activities of the chemical industry in this field. An as yet unsolved problem involves the stability of collector plates. But definite progress was achieved in this field in recent times. The best figures currently give us an efficiency of 40 percent with one year of illumination out in the open.

5058
CSO: 3102/350

ENERGY

EUROPE'S LARGEST COAL HYDROGENATION PLANT IN OPERATION

Plant in Bottrop

West Berlin DER TAGESSPIEGEL in German 9 Jul 81 p 1

> [Text] With the push of a button yesterday, Minister President Rau of Nordrhein-Westfalen set Europe's largest coal hydrogenation plant into operation. The plant, in Bottrop, will produce some 140 metric tons of light oil and mineral oil daily, as well as gaseous products, from about 200 tons of bituminous coal. These products will be further processed for the fuel, heating and chemicals market at the Veba refinery in Geisenkirchen-Scholven. A special procedure was developed in Scholven for this purpose.

The Bottrop project, which was completed in 2 years, is expected to cost DM 420 million, including projected operating costs till 1983. The Land of Nordrhein-Westfalen had a 90-percent share in the total investment of DM 220 million. The plant has a total personnel of 215 employees. Yearly operation is expected to cost about DM 65 million.

Specifically, 70 tons of middle oil, 30 tons of light oil, 20 tons of liquefied gas and 20 tons of heating gas will be produced from the 200 tons of coal each work day. These will be further processed to heating oil, diesel fuel and carbureted fuel, as well as to synthetic gasoline. In the next few years the new Bottrop plant is expected to provide the necessary experience and data for planning, building and operating a large-scale plant, whose construction is envisioned to begin some time yet this decade. A definite site has not yet been found, however. According to a statement by Bund, the chairman of the board of directors of Ruhrkohle AG, gasoline from this plant would cost about DM 1.85 per liter, based on the current price situation for the use of German coal and on the same taxes. Coal refining plants have thus still not become fully competitive, but it is nonetheless certain that the gap will become increasingly smaller.

Forty-five years ago, on 7 July 1936, in a plant in Scholven, not far from the Bottrop site, gasoline was obtained from bituminous coal for the first time anywhere in the world. After further plants ahd gone into operation there, a yearly capacity of nearly 5 million tons was reached until 1940. That was some 25 percent of today's gasoline consumption in the FRG.

Minister President Rau said that the startup of the experimental plant was not the "starting gun for a large-scale, unlimited coal refining policy." It is, however, a bit of assurance for the future in that the FRG is mastering some new technology. All in all, coal liquefication still has a long way to go before it becomes economically feasible, even if this way were to be facilitated by extensive government support. There is simply no way around a thrifty and rational use of energy. This is and shall remain the prime goal of the FRG's energy policy.

New Technology

Duesseldorf VDI NACHRICHTEN in German 17 Jul 81 p 1

[Excerpts] The plant in Bottrop works by a process of catalytic coal liquification which was developed from the earlier IG process as "new German technology."

The hydrogenation reactors are the core of the experimental plant. The hydrogenation reaction takes place at a pressure of 300 bar and a temperature of 475°C, with a throughput time of about 45 minutes. A mixture of liquid and gaseous hydrocarbons is produced. The raw produce consisting of liquid and gaseous hydrocarbons still contains small amounts of undissolved coal as well as nonreactable mineral impurities from the starting coal. After leaving the last hydrogenation reactor, this crude product must still be processed further in several steps.

Special consideration was given in the Bottrop project to make sure the plant would not pollute the environment. The chemical processes take place in closed systems, so that emissions are not to be expected. But all the other operations in the process--such as bringing in the coal on conveyor belts from the near-by coking plant and the drying and grinding of the coal--are also sealed off from the exterior. Flue gases and other exhausts are purified before being released into the air, so that the emissions are far below the permissible levels in the "technical manual for air." Approximately 20 percent of the total money investment was used for environmental-protective devices, including a protection against noise.

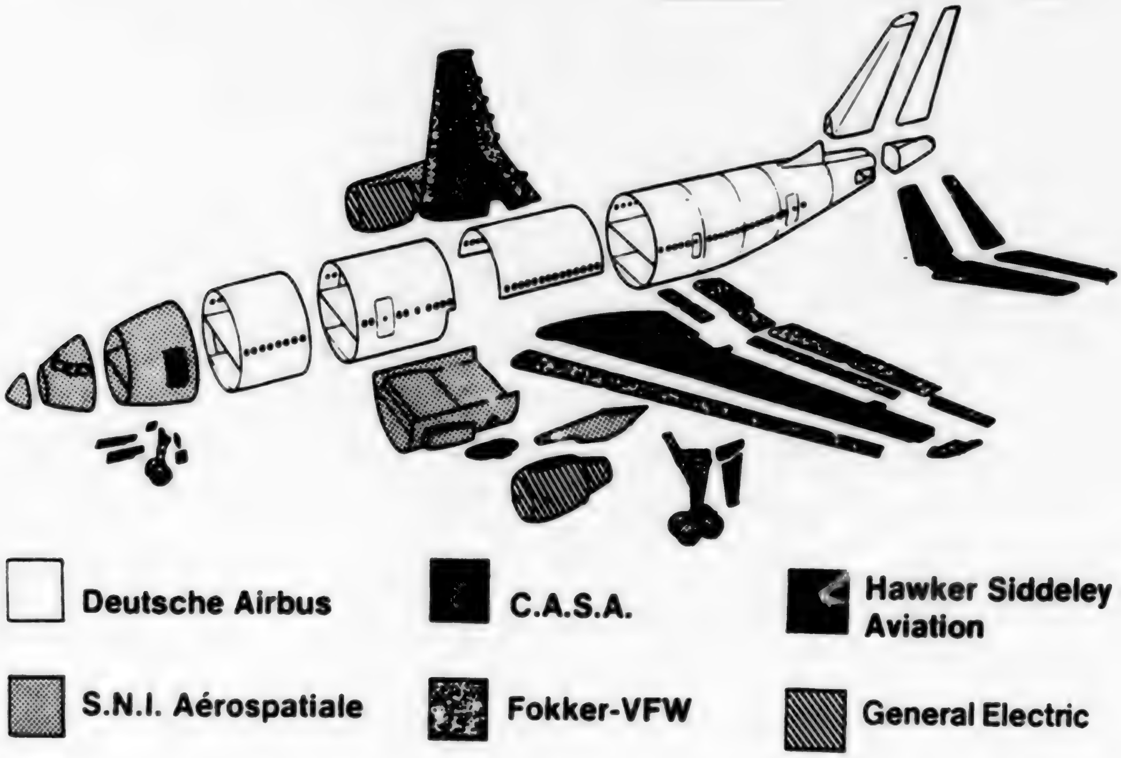
8838
CSO: 3102/367

TRANSPORTATION

AIRBUS NUMBER TWO IN WORLD

Bern TECHNISCHE RUNDSCHAU in German No 23, 2 Jun 81 pp 21, 23

[Excerpt] Airbus Industries (AI) is now second in annual sales; with its A300/310 family, it could build up a wide monopoly area in Europe, the Near East and Southeast Asia. Whether and when the program is expanded upward with the A330 and A340 (formerly the TA9 and TA11) or downward with the A320 (formerly the SA-1 and -2) depends among other things mainly on the financial capabilities of the states and firms having an interest in AI.



In all, seven firms are involved in building the A300/310; Pratt & Whitney has recently joined. This engine manufacturer fitted out an A300 for the first time in 1980 and has been able to book various important orders for itself in the meantime, for instance the Swissair A310. (Lufthansa illustration)

8545
CSO: 3102/357

TRANSPORTATION

SWEDISH STATE RAILWAY STUDIES HYDROSTATIC DRIVE FOR TRAINS

West Berlin ZEITSCHRIFT FUER EISENBAHNWESEN UND VERKEHRSTECHNIK in German No 6, Jun 81 pp 184-185

[Article: "Hydrostatic Drive for Trains"]

[Text] Hydrostatic drive and braking are currently being tested within the Swedish State Railway (SJ) program for studying the use of new, operationally efficient power transmission systems. In this process, hydropumps and hydromotors supply energy to the wheels for acceleration and withhold it for braking. The basic principle of this method of power transmission is not new, but the control equipment fitted to the hydrodevice and the previously unattained efficiency of the hydraulic machines employed certainly are. The automatic control technology and the hydraulic components are spin-offs from Volvo Flygmotor's jet engine production.

Volvo Flygmotor AB (VFA) has been making high-quality hydraulic machines that are characterized by good efficiency since the beginning of the seventies. On the basis of these qualities, complete power transmissions were investigated as an alternative to existing systems in a Swedish State Railway study with the Imperial Department for Aid to Technical Development (STU). In this study, the system components of the power transmission of railroad vehicles were determined. System control capabilities were investigated first with an analog machine. Since the results were encouraging, practical tests were begun.

In April 1979, a contract was concluded between the Swedish State Railway and Volvo Flygmotor AB which provided for converting an X9 series train for hydrostatic drive and testing the system on the Swedish State Railway network to develop it further. STU financial support was a contract requirement.

In the summer of 1979, the drive unit was assembled, and in the winter of 1979/80, test driven on a motor test stand at the VFA together with the electronic control equipment. The main machine shop of the Swedish State Railway at Amal performed the necessary conversion and installation, and in May 1979, the vehicle was ready for testing.

Cooperative testing by the Swedish State Railway and VFA has been underway since May 1980 (figure 1).

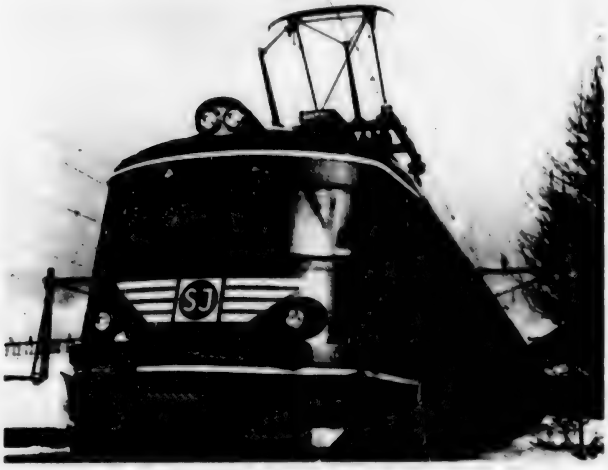


Figure 1. Swedish State Railway Experimental X9 Series Railcar

Time planning and the cost calculations of the study were handled by a project group made up of three representatives each from the Swedish State Railway and VFA. This group has also continuously evaluated the project and is responsible for the final report to be submitted to the imperial department. VFA is responsible for detailed planning and implementation and is actively supported in this by the Swedish State Railway main machine shop in Amal.

Track trials were conducted by a Swedish State Railway engineer and two to four VFA engineers. The engineer had to coordinate with the other railroad traffic and was responsible for train operation and safety on board. VFA personnel conducted the tests and were responsible for the installed equipment as well as evaluation of the results.

The HP1 is a modified railcar of the four-part X9 type. An intermediate car was left out. Seats were removed from the middle car and the resulting free space used for two identical drive units. Through a transfer case, a diesel motor drives two hydraulic pumps with variable capacity. Through flexible hoses, each pump supplies a hydraulic motor with a constant amount of hydraulic oil. The motor drives the wheel axle through an axle-mounted gear transmission. In all, 4 of the 12 wheel axles on the train are driven this way. The other axles are not driven and run free.

All the seats and interior equipment in the front control car (with the sliding current contact) were left intact. The driver's cab was modified, however, to house the controls for the new power transmission system.

Some seats were removed in the rear control car to make room for the computer, electronic and recording equipment. The driver's cab was modified in the same way as in the front car.

When the train is standing still, the pumps pump no oil, but the drive motor, a diesel in this case, is in operation and drives the pumps. Through progressively

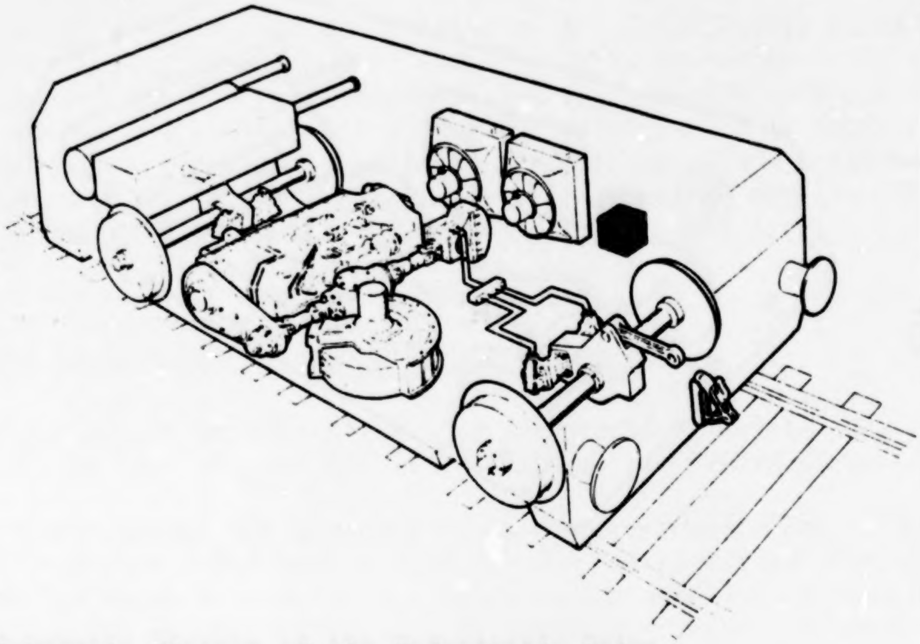


Figure 2. Schematic Diagram of the Hydrostatic Drive

increasing pump delivery from zero to full capacity, the train is set in motion and accelerated. It should be noted that in the process the pump rate is not changed, which opens attractive prospects for light, cheap and sturdy asynchronous motors as drive sources.

Travel direction is easily changed by reversing the oil flow. By reversing the pressure ratios in the system, the hydrostatic power transmission is used as a brake. When capacity is slowly decreased, the hydraulic motor at the double axle transmission operates as a pump driven by the rolling train and pressurizes the variable hydraulic pump with high-pressure oil. The latter is driven by the oil and operates as a motor. A retarder mounted on the diesel motor shaft converts the occurring brake energy into heat that is dissipated by cooling. This has produced a brake device that requires no action on the wheels whatsoever. This braking is effective over the entire drive area, wears out neither wheels nor brake shoes and operates very gently, smoothly and without annoyance for the passengers. The well-known difficulties due to skidding or locking wheels during acceleration or braking can be avoided. The hydrostatic power transmission requires a highly developed control system. Thanks to their experience in aeronautics, Volvo Flygmotor has the necessary know-how to develop such systems.

The main item in the control system is a microcomputer that contains the stored logic, records the engineer's actions, evaluates information on speed, pressure and rate among other things, and generates the required control signals for the execution of drive commands such as braking, acceleration, steady cruising, etc.

The engineer is provided with just one control panel to select a number of operating conditions:

- uniform acceleration to the desired speed, with gentle startup;
- maintenance of attained speed whereby the computer automatically carries out the adjustments for up- or down-grades;

-- freewheeling of the train whereby the diesel has to compensate merely for the idling losses of the device;
-- optional, selectable deceleration values using hydrostatics whereby good travelling comfort is maintained; and
-- engagement of normal friction brakes, which are used however only as backups.

The computer samples each time the status of the drive governor, the speed and instantaneous performance of the diesel motor, delivery rating of the hydraulic pump, oil pressure of the hydraulic device, wheel speed as well as a number of monitoring signals. The computer interprets the sampled information and issues the appropriate control commands for the output regulator of the diesel motor, the capacity of the hydraulic pump and the retarder.

Aberrations, e.g. wheel skiddings, are detected and corrected in fractions of a second without engineer intervention. The computer is also capable of determining device malfunctions by location and magnitude and upon determination, automatically taking the necessary measures to counter serious malfunctions. The engineer is informed of a malfunction on a malfunction indicating panel.

The main purpose of the project is to develop and specify the control system for a hydrostatic power transmission, as well as to gather supporting data to develop components that are suitable for railroad service. Malfunction effects on the electronic units in the form of main voltage losses and encounters with Rc type thyristor locomotives were studied. No difficulties occurred with this. Maintenance of a constant speed, i.e. the capability of the control system to maintain a specified speed in mountainous terrain, was studied. As an example, it was stated that the train showed a maximum deviation of ± 2 km/h at 80 km/h.

Stable acceleration, a desirable feature to provide good passenger comfort, was realized with the HP1 system. Stable deceleration means gentle and smooth braking of the train. Thanks to the capability of hydrostatically braking the entire drive range to zero without having to use the friction brakes, this feature was achieved.

Vibrations occurring in the drive unit and the two-axle bogie were recorded. This work was of use primarily in developing hydraulic motors for railroad service. Preliminary results indicate that the motors are exposed to no especially detrimental vibrations.

Much attention was paid to the slip/skid control system, i.e. the monitoring of the friction between the wheels and the track. The tests are aimed at finding ways to detect wheel skidding or locking during acceleration or braking in the beginning phase. The Swedish State Railway annually suffers extensive damage to wheels and rails, mainly through locked wheels during braking. Up to now, skidding or locking has occurred with hydraulic power transmission when pressure dropped rapidly. Since the rotating mass, compared with, for example, electric motors, is very small, a rapid and precise control system is required. A recently installed computer with expanded capabilities will further improve achievable results. A series model of the slippage detection system should be offered at a competitive price.

The HP1 project was aimed primarily at developing a system for effective control and regulation of a hydrostatic power transmission.

Coming projects are aimed at designing installation sections suitable for production as well as research efforts focusing on reliability, durability and maintainability. In addition, the work installed on this particular vehicle has to be even better coordinated.

8545
CSO: 3102/357 END

END OF

FICHE

DATE FILMED

28 Aug. 1981